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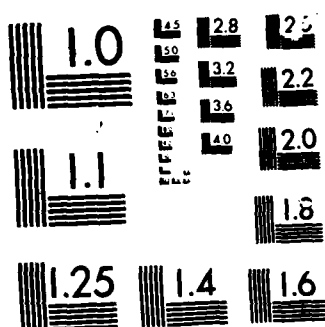
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FINAL REPORT

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ANALYSIS, MODELING AND CONTROL OF DYNAMICAL SYSTEMS

**Lefschetz Center for Dynamical Systems
Division of Applied Mathematics
Brown University
Providence, RI 02912**

Principal Investigators

**H. T. Banks
J. K. Hale**

Report prepared by:

H. T. Banks

covering the period October 1, 1983 - September 30, 1984

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Final Report
AFOSR Grant 81-0198

Banks has continued his efforts on computational methods in control and parameter estimation problems governed by partial differential equations. In [1] and [5] techniques for estimation of variable coefficients and boundary parameters in hyperbolic systems was considered. Both spline and tau-Legendre methods were employed. Parameter estimation techniques for problems involving higher order continuum models were developed and reported on in [2]. In [3], [7] and [8], techniques for estimation in elliptic problems arising in antenna surfaces was investigated. Problems with time and spatially dependent transport parameters in parabolic systems were treated in [6] and [9]. Methods for computation of feedback gains for optimal control of a quite general class of parabolic systems was investigated in [4].

For systems of reaction-diffusion equations with Neumann boundary conditions, Hale [11] has shown that, if the diffusivities are large, then the flow behaves as the corresponding ode's. No assumption on the existence of invariant regions is made. This is a significant generalization of work of Conway, Hoff and Smoller. Hale and Rocha [12], using some of the ideas from [11] have discussed the effects of the boundary conditions on the flow for large diffusivity. The flow still is governed by an ode but not the one given by the vector field in the original equation. Work is continuing in this direction.

Hale, Lin and Raugel have obtained some partial results on the numerical approximation of the attractor for abstract evolutionary equations, which include reaction-diffusion systems, Navier-Stokes equation and certain types of hyperbolic systems.

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INVERSE PROBLEMS FOR HYPERBOLIC SYSTEMS
WITH UNKNOWN BOUNDARY PARAMETERS^{*}

H. T. Banks

and

K. A. Murphy

ABSTRACT

We discuss spline based approximation techniques for a particular class of parameter estimation problems for the wave equation. Specifically we consider a 1-D acoustic or elastic wave equation with unknown parameters in elastic boundary conditions on one boundary and in absorbing boundary conditions on the other as well as in the equation itself. Both theoretical convergence results and numerical examples are presented for such model seismic inverse problems.

PARAMETER IDENTIFICATION IN CONTINUUM MODELS

by

H. T. Banks and J. M. Crowley

ABSTRACT

We discuss approximation techniques for use in numerical schemes for estimating spatially varying coefficients in continuum models such as those for Euler-Bernoulli beams. The techniques are based on quintic spline state approximations and cubic spline parameter approximations. Both theoretical and numerical results are presented.

Modeling of Flexible Surfaces: A Preliminary Study

H. T. Banks and G. Majda

ABSTRACT

We give a careful derivation of the 1-dimensional classical scalar "string" equation which involves linearization about a horizontal reference or equilibrium position. We then derive a model for "small motion" about a nonhorizontal reference. The implications of our findings to modeling of flexible antenna surfaces such as that in the Maypole Hoop/Column antenna are discussed.

The Linear Regulator Problem for Parabolic Systems

H. T. BANKS

K. KUNISCH

ABSTRACT

We present an approximation framework for computation (in finite dimensional spaces) of Riccati operators that can be guaranteed to converge to the Riccati operator in feedback controls for abstract evolution systems in a Hilbert space. It is shown how these results may be used in the linear optimal regulator problem for a large class of parabolic systems.

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COMPUTATIONAL METHODS FOR ESTIMATION OF
PARAMETERS IN HYPERBOLIC SYSTEMS

H. T. Banks^{*}, K. Ito[†] and K. A. Murphy^{*}

Abstract. We discuss approximation techniques for estimating spatially varying coefficients and unknown boundary parameters in second order hyperbolic systems. Methods for state approximation (cubic splines, tau-Legendre) and approximation of function space parameters (interpolatory splines) are outlined and numerical findings for use of the resulting schemes in model "1-D seismic inversion" problems are summarized.

ESTIMATION OF TEMPORALLY AND SPATIALLY
VARYING COEFFICIENTS IN MODELS FOR
INSECT DISPERSAL

H. T. Banks, P. L. Daniel Lamm and P. M. Kareiva

ABSTRACT

We describe techniques for estimating temporally and spatially dependent parameters (including coefficients) that appear in general transport models. Convergence properties of the resulting algorithms are given and sample computational findings with test examples are presented. We conclude with a summary of our use of the methods analyzing experiments on the movements of marked flea beetles in cultivated arrays of the cole crop, collards (*Brassica oleraceae*).

Spline-Based Estimation Techniques for Parameters
in Elliptic Distributed Systems

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Abstract

Parameter and state estimation techniques are discussed for an elliptic system arising in a developmental model for the antenna surface in the Maypole Hoop/Column antenna. A computational algorithm based on spline approximation for the state and elastic parameters is given and numerical results obtained using this algorithm are summarized.

A Spline-Based Parameter and State Estimation Technique
For Static Models of Elastic Surfaces

May, 1983

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Abstract

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Research reported here was supported in part by NASA Grant NAG-1-258 for the first and second authors, in part by NSF Grant MCS-8205355 and in part by AFOSR Grant 81-0198 for the first author, and NSF Grant MCS-8200883 for the second author. Parts of the efforts reported were carried out while the first two authors were in residence at the Institute for Computer Applications in Science and Engineering, NASA Langley Research Center, Hampton, VA, which is operated under NASA Contracts No. NAS1-15810 and No. NAS1-16394.

ESTIMATION TECHNIQUES FOR TRANSPORT EQUATIONS

by

H. T. Banks, P. L. Daniel and P. Kareiva

ABSTRACT

We present convergence arguments for algorithms developed to estimate spatially and/or time dependent coefficients and boundary parameters in general transport (diffusion, advection, sink/source) models in a bounded domain $\Omega \subset \mathbb{R}^2$. A brief summary of numerical results obtained using the algorithms is given.

Large Diffusivity and Asymptotic Behavior
in Parabolic Systems

by

Jack K. Hale

Abstract

For systems of reaction-diffusion equations with Neumann boundary conditions, it is shown that the solutions are asymptotic to the solutions of an ordinary differential equation if the diffusivity is large. The methods apply also to reaction-diffusion systems with time delays.

VARYING BOUNDARY CONDITIONS
WITH LARGE DIFFUSIVITY

by

Jack K. Hale and Carlos Rocha

ABSTRACT

For systems of semilinear parabolic partial differential equations on bounded domains with large diffusivity and homogeneous boundary conditions close to the Neumann conditions, we associate a system of ordinary differential equations (ode's) from which the dynamics of the original system can be inferred. Small perturbations of the Neumann case produce large perturbations in the ode's with corresponding effects on the dynamics of the system. The same theory is valid for functional differential equations. Applications are considered in models for control by genetic repression of biological material in cells.

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